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FOAMING OF MILK AND CREAM

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The foaming of milk and cream is a condition met with in many milk plants. It often results in much loss of both product and labor. Foam present in pasteurizers during the pasteurization process may become a public-health problem.[1] The present investigation was undertaken for the purpose of studying the following factors, which it was believed might be responsible, in whole or in part, for the phenomenon: Butterfat content, temperature, age, agitation, pasteurization, and vacuum.

PROCEDURE

The milk and cream used in this investigation were procured from the mixed-herd milk from the Bureau of Dairy Industry experimental farm at Beltsville, Md. In all these experiments skim milk, milk containing 3 per cent and 5 per cent butterfat, and cream containing 18 per cent butterfat were used. In this study a mixture of the morning's and the previous evening's milk constitutes fresh milk. The experiments were made in the morning and the various ages were computed from that time. The Babcock test was used in determining the butterfat percentage of the milk and cream.

The apparatus used in producing foam consisted of a 60 c. c. burette inserted through a water bath. The lower end of the burette extended through and below the bottom of the water bath to such a degree as to allow the operation of the pet cock. This was made possible by the construction of a stuffing box in the bottom of the water bath. The material studied was run from the burette into a 100 c. c. graduated cylinder. The apparatus was so placed as to allow a fall of 15 inches from the lower end of the burette to the bottom of the cylin-

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[1] Whittaker, H. A., Archibald, R. W., Leete, C. S., and Miller, L. F. A comparison of the temperature and bacterial count of milk and foam during certain stages of the pasteurization process. U. S. Dept. Agr. Tech. Bul. 18, 11 p., illus. 1927.

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der. The temperature of the milk and cream was regulated by that of the water bath, which was adjusted to a temperature 1.5° C. higher than that at which observations were to be made. This excess in temperature over that desired was found to care for the loss in temperature which occurred in pouring the milk or cream into the burette. The milk or cream was heated in a flask immersed in the water bath and was then poured into the burette. Twenty-five cubic centimeters were allowed to flow, with a straight fall, into the 100 c. c. graduated cylinder. The line of demarcation between the foam and the milk was distinct, thus enabling accurate measurements of the foam to be made. Measurements were made immediately after the flow had ceased, and also one minute later.

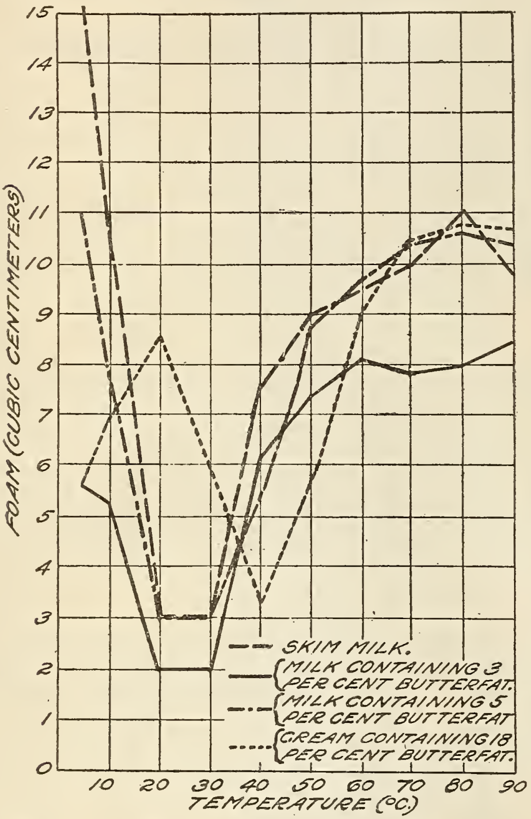

FIGURE 1.—Effect of butterfat content and temperature on foaming ability of milk and cream (immediate measurements)

DISCUSSION OF RESULTS

BUTTERFAT CONTENT

The formation of foam on milks of different butterfat content and the cream used in this experiment was determined at various temperatures and ages. A study of the data shows that no definite statement can be made regarding the effect of butterfat without considering temperature.

TEMPERATURE

A study of the results obtained in this investigation shows that temperature is one of the major factors governing the amount of foam produced on milk and cream. (Figs. 1 and 2.) The foam formed on milk of low butterfat content and at low temperatures was light and airy. The bubbles were large. At higher temperatures the foam bubbles became smaller and more numerous. With cream the general trend was the same as with milk, except that at all temperatures the bubbles were smaller than those formed on the milk.

When immediate measurements were made, the temperatures at which the least foam was formed were identical for all the milks,

i. e., 20° and 30° C. From 30° to 80° there was an increase in the amount of foam produced. At 90° both the skim milk and milk containing 5 per cent butterfat gave slightly less foam, whereas the milk containing 3 per cent butterfat showed a slight increase. At temperatures below 20° the amount of foam increased for all the milks, the maximum amount of foam being formed at 5° by the skim milk and milk containing 5 per cent butterfat; at 90° the milk containing 3 per cent butterfat forms the maximum amount of foam.

Different results were obtained from the cream studied. The amount of foam produced was least at 40° C. and increased up to 80°, at which temperature the maximum foam production was reached. At 90° there was a slight decrease. The amount of foam increased from 40° to 20° and gradually decreased from 20° to 5°.

When 1-minute measurements were considered, it was seen that although the relative amount of foam formed at each temperature was comparable to the amount registered by the immediate measurements, the actual amounts were somewhat smaller. This was especially true at temperatures below the point at which the minimum amount of foam was formed. As the temperature increased, the difference between the immediate and 1-minute measurements grew smaller. The maximum amount of foam was formed at 90° C. for the cream and all milks except the skim milk, the maximum amount for which was formed at 80°.

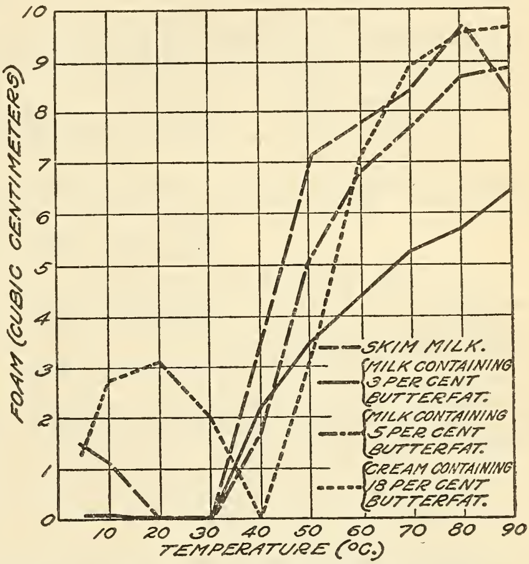

FIGURE 2.—Effect of butterfat content and temperature on the foaming ability of milk and cream (1-minute measurements)

AGE

All milks and cream were aged at a temperature of 10° C. Both immediate and 1-minute measurements were recorded. A study of these measurements reveals that aging in general had but little effect upon the formation of foam on either milk or cream, with the exceptions of the skim milk at 5° and 10°. At these temperatures the immediate measurements showed progressive increases in the amount of foam after 24 and 48 hours and then a decided falling off in amount at 72 hours, the amount of foam at this age being less than that on the fresh milk. Such a condition was not reflected in the 1-minute measurements. (Table 2.)

PASTEURIZATION

In order to determine what effect, if any, pasteurization has upon the formation of foam, the various milks and cream were pasteurized at 62.5° C. for 30 minutes and immediately cooled to 5°. The results obtained are given in Table 1. According to immediate measurements, the fresh raw milks gave more foam than the pasteurized milks, whereas the 1-minute measurements showed the reverse. In the case of skim milk that had been held 24, 48, and 72 hours the immediate measurements were larger than the 1-minute measurements, but the 1-minute measurements of foam on the raw and pasteurized milk containing 3 per cent and 5 per cent butterfat were identical.

Table 1.—*Effect of pasteurization at 62.5° C. for 30 minutes upon the foaming of milk and cream of different ages*

Item	Quantity of foam in milk and cream of age stated when measured immediately and one minute later							
	Fresh		24 hours old		48 hours old		72 hours old	
	Immediate	One minute	Immediate	One minute	Immediate	One minute	Immediate	One minute
Skim milk:	*C. c.*	*C. c.*	*C. c.*	*C. c.*	*C. c.*	*C. c*	*C. c.*	*C. c.*
Raw	32.00	2.00	33.00	2.00	35.00	3.00	34.00	3.30
Pasteurized	29.37	6.25	31.75	5.82	31.87	4.75	30.88	3.82
Milk containing 3 per cent butterfat:								
Raw	28.00	1.00	29.50	1.00	30.50	1.00	30.50	1.00
Pasteurized	24.63	2.27	28.72	1.00	28.31	1.00	28.27	1.00
Milk containing 5 per cent butterfat:								
Raw	29.50	2.00	30.50	1.00	30.50	1.00	32.00	1.00
Pasteurized	26.75	2.28	28.09	1.00	28.42	1.00	29.80	1.00
Cream containing 18 per cent butterfat:								
Raw	23.00	1.00	25.00	2.00	25.00	2.00	26.00	3.00
Pasteurized	23.22	1.00	24.77	1.00	25.11	1.00	26.33	1.00

A somewhat different condition was found in the case of pasteurized cream and raw cream. Pasteurization had very little effect upon the formation of foam as recorded by the immediate measurements. The 1-minute measurements for the fresh cream were the same for both the raw and pasteurized samples. After being held 24, 48, and 72 hours, however, the raw cream gave very much greater measurements than the pasteurized. This is the reverse of the findings for the skim milk.

AGITATION

To determine the effect of agitation upon the formation of foam, studies were made with the various milks and cream at temperatures from 5° to 90° C. and at various ages. The procedure was identical with that already described, except that the diameter of the outlet of the burette was doubled, a greater flow to the cylinder thus resulting. An increased momentum was therefore set up, which in turn exerted a greater force upon the body of liquid into which the stream was directed. The effect of agitation due to this change in momentum was therefore studied. In all cases increased agitation produced a greater amount of foam.

VACUUM

Studies were also made to determine the effect of agitation in a vacuum. The various milks and the cream were agitated in flasks after the air had been removed to a pressure of less than 1 millimeter of mercury. Determinations were made at 5°, 30°, and 50° C. Controls were run, conditions being identical, with the exception of air pressure. Foam was developed by shaking the flasks. Results in all cases showed little, if any, difference in the amount of foam produced by the samples in vacuo and those under normal atmospheric pressure.

STABILITY OF FOAM

Table 2 shows the percentage of foam remaining one minute after immediate measurements were taken for the milks and cream at various ages and at different temperatures. The data show that temperature is a major factor in regard to the stability of foam. In general, low temperatures did not produce a stable foam, whereas higher temperatures produced foam which was quite persistent.

Table 2.—*Stability of foam of milks and cream of various ages and at different temperatures as measured by the percentage remaining one minute after immediate readings*

Material and age	Percentage of foam remaining after one minute, at—									
	5° C.	10° C.	20° C.	30° C.	40° C.	50° C.	60° C.	70° C.	80° C.	90° C.
Skim milk:										
Fresh	9.6	11.1	0	0	47.5	79.4	81.0	84.4	87.9	85.6
24 hours	9.1	8.6	0	0	42.0	70.4	77.9	86.9	84.3	87.6
48 hours	9.8	9.1	0	0	43.5	75.2	82.9	84.5	83.6	86.0
72 hours	11.4	10.8	0	0	44.3	80.6	86.4	87.4	89.8	97.6
Milk containing 3 per cent butterfat:										
Fresh	0	0	0	0	36.1	47.8	54.4	67.0	70.1	76.3
24 hours	0	0	0	0	35.4	51.6	54.9	63.8	72.5	79.6
48 hours	0	0	0	0	36.1	51.3	56.4	64.6	74.6	74.0
72 hours	0	0	0	0	36.1	51.2	61.6	67.7	76.8	80.0
Milk containing 5 per cent butterfat:										
Fresh	0	0	0	0	33.2	59.5	70.3	74.2	82.7	85.8
24 hours	0	0	0	0	31.2	57.2	66.5	79.3	80.3	85.9
48 hours	0	0	0	0	35.9	58.3	70.5	77.6	82.1	85.2
72 hours	0	0	0	0	33.2	57.1	61.3	78.2	84.1	84.5
Cream containing 18 per cent butterfat:										
Fresh	22.8	38.1	36.0	32.8	0	55.4	80.0	83.9	89.2	90.6
24 hours	28.8	42.7	44.8	39.2	0	54.4	75.3	87.7	89.9	91.3
48 hours	35.4	40.0	47.6	45.4	0	60.5	75.8	93.1	87.9	90.6
72 hours	27.6	45.3	51.4	43.3	0	55.4	77.4	82.1	87.8	89.3

Those temperatures at which the least amount of foam was formed were the temperatures at which the least stable foams were formed. As the temperatures increased above the point of minimum production—20° and 30° C. for milks and 40° for the cream—the stability of the foam increased. This held true up to 70°. At 80° and 90° the amount of foam remaining after one minute varied but slightly from that found at 70°. For the milks the stability of foam was approximately the same at temperatures of 50° to 90°, whereas the cream showed approximately the same amount of foam at temperatures of 60° to 90°.

At low temperatures, 5° and 10° C., the skim milk produced a foam which was slightly stable (9–11 per cent), whereas the stability of the foam on milks containing 3 and 5 per cent butterfat at these temperatures was nil.

With the cream at 5° to 30° C., a somewhat different condition was found. At these temperatures the amount of foam remaining after one minute varied from approximately 23 to 51 per cent, the lower percentage being at 5° C. At 10°, 20°, and 30° the stability of the foam varied but little. At these temperatures, however, it was considerably more stable than at 5°. At 40°, the temperature at which cream foams the least, the foam, after one minute, practically disappeared.

Age had little if any effect upon the stability of foam. This was true for all the milks and cream studied.

SUMMARY

Skim milk and milk containing 3 and 5 per cent butterfat formed the least foam at 20° to 30° C. At lower temperatures larger amounts of a light airy foam were produced, whereas generally increasing amounts of a heavier foam occurred at temperatures from 30° to 80°. Cream containing 18 per cent butterfat formed the least foam at 40°. From 40° to 80° and from 40° to 20° the amount of foam increased as the temperature increased or decreased.

Aging milk and cream for 24, 48, and 72 hours had little effect on the formation of foam.

The immediate measurements of the foam on raw skim milk were greater than those on pasteurized milk, whereas the reverse was true of the 1-minute measurements. Immediate measurements of raw milks containing 3 and 5 per cent butterfat showed more foam than did immediate measurements of pasteurized milks. One-minute measurements were the same for both raw and pasteurized samples held 24, 48, and 72 hours, whereas the fresh samples of pasteurized milk showed more foam than did those of raw milk. One-minute measurements were the same for both raw and pasteurized cream. After being held 24, 48, and 72 hours the raw cream formed much more foam than did pasteurized cream. The contrary was true of skim milk.

With all milks and cream studied, increased agitation resulted in increased amounts of foam. Results showed that foaming took place in vacuo to approximately the same degree as under atmospheric pressure.

One-minute foam measurements were relatively the same as immediate measurements. The actual measurements, however, were smaller. As the temperature increased the difference between the immediate and 1-minute measurements lessened.

In general, low temperatures (5° to 30° C.) do not produce a stable foam, whereas the higher temperatures (40° to 90°) produce a foam which is quite stable.

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